

**WHAT IS CLAIMED IS:**

5        f. An image display apparatus comprising:  
reflective display means;  
illumination light source means for illuminating  
the display means;  
an illumination optical system for guiding light  
from the illumination light source means to the display  
means; and  
10      a display optical system for guiding light from  
the display means to an eye of an observer,  
wherein the illumination optical system and the  
display optical system share only one surface of  
optical surface A having two functions of transmission  
and reflection with each other, wherein a reference ray  
15      emitted from the illumination light source means and  
passing a center of an image on the display means and a  
center of the eye is incident from the illumination  
light source means to the optical surface A, is  
reflected under a condition of an angle  $\alpha(^{\circ})$  of  $20 < \alpha$   
20       $< 80$  between the entering reference ray and the  
reflected reference ray on the optical surface A, is  
incident substantially normally to the display means,  
is reflected thereby, is transmitted through the  
optical surface A, is reflected by a plurality of  
25      decentered, reflective curvature surfaces, and  
thereafter is guided to the eye, and wherein the  
display optical system is comprised of an optical

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member comprising the optical surface A and another optical member having an optical refracting power, said optical members being placed with an air space in between.

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2. The image display apparatus according to Claim 1, wherein the optical surface A in the illumination optical system is a reflective curvature surface having a positive refracting power on a local meridional section (a plane including incident light and exit light of the reference ray).

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10 3. The image display apparatus according to Claim 1, wherein the illumination light source means is an RGB time division light source and the display means displays images of R, G, and B in time division in synchronism with emission of color light beams of R, G, and B from the RGB time division light source.

15 20 4. The image display apparatus according to Claim 1, wherein an angle  $\beta(^{\circ})$  of incidence to the reflective display means, of the reference ray emitted from the illumination light source means satisfies the following condition:

25  $-10 < \beta < 10.$

5. The image display apparatus according to Claim

2 or 3, wherein the display optical system includes two or more surfaces with refracting powers differing depending upon azimuth angles, and the entire display optical system has a positive refracting power.

5                 6. The image display apparatus according to Claim  
5, wherein in an outermost image on a local meridional  
section of the display means (a plane including  
incident light and exit light of the reference ray), an  
10 F3 eye center ray represents a ray passing the center  
of the eye and an outermost image on the far side from  
the eye, local\_fy(F3) is a total focal length in the  
local meridional section of the display optical system  
on the F3 eye center ray, local\_fyC(F3) is a focal  
length in the local meridional section on a hit point  
15 of the F3 eye center ray on a transmissive surface C  
with a refracting power closest to the eye, and a ratio  
of the focal lengths satisfies the following condition:  
-0.6 < local\_fy(F3)/local\_fyC(F3) < -0.1.

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7. An image display apparatus comprising:  
reflective display means;  
illumination light source means for illuminating  
the display means;  
25 an illumination optical system for guiding light  
from the illumination light source means to the display  
means; and

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a display optical system for guiding light from the display means to an eye of an observer,

wherein an optical surface A having two functions of transmission and reflection, shared between the 5 illumination optical system and the display optical system, has a curvature on a local meridional section (a plane including incident light and exit light of a reference ray emitted from the illumination light source means and passing a center of an image on the display means and a center of the eye), wherein when 10 local\_fy represents a focal length in the local meridional section of the display optical system and local\_fyA a focal length in the local meridional section of only the optical surface A in the 15 illumination optical system, a ratio of the focal lengths satisfies the following condition:

$$0.1 < \text{local\_fyA}/\text{local\_fy} < 1.0,$$

wherein rays emitted from the illumination light source means are reflected by the optical surface A to 20 illuminate the display means and the reflected light from the display means is transmitted through the optical surface A, is reflected by a plurality of reflective surfaces, and thereafter is guided to the eye.

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11. The image display apparatus according to Claim 10, wherein the optical surface A having the two

functions of transmission and reflection, shared between the illumination optical system and the display optical system, comprises only one surface.

5 12. The image display apparatus according to Claim 10, wherein the plurality of reflective surfaces in the display optical system are decentered curvature surfaces.

10 13. The image display apparatus according to Claim 10, wherein the display optical system is comprised of an optical member comprising the optical surface A and another optical member having an optical refracting power, said optical members being placed 15 with an air space in between.

14. The image display apparatus according to Claim 10, 13, or 13, wherein the illumination light source means is an RGB time division light source and the display means displays images of R, G, and B in time division in synchronism with emission of color light beams of R, G, and B from the RGB time division light source.

25 15. The image display apparatus according to Claim 10, wherein the display optical system includes two or more surfaces with refracting powers differing

depending upon azimuth angles, and the entire display optical system has a positive refracting power.

13. An image display apparatus comprising:  
5      reflective display means;  
0      illumination means for illuminating the display  
means;  
0      an illumination optical system for guiding light  
from the illumination means to the display means; and  
5      a display optical system for guiding light from  
the display means toward an observer,  
0      wherein the illumination optical system and the  
display optical system share an optical surface A  
having two functions of transmission and reflection  
5      with each other, the optical surface A has a curvature  
on a local meridional section (a plane including  
incident light and exit light of a reference ray  
emitted from the illumination means and passing a  
center of an image on the display means and a center of  
0      the pupil), a curved surface B is provided on the  
opposite side of the optical surface A to the display  
means, and the optical surface A and optical surface B  
compose a lens body, wherein rays emitted from the  
illumination means are reflected by the optical surface  
5      A of the lens body to illuminate the display means, and  
the reflected light from the display means is  
transmitted by the optical surface A to enter the lens

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5 body and then emerge from the optical surface B, is then reflected by a plurality of reflective surfaces, and thereafter is guided to the pupil to form an enlarged image of the image displayed on the display means, and wherein when local\_ryA represents a radius of curvature in the local meridional section, at a point of intersection with the reference ray on the optical surface A of the lens body in the display optical system and local\_ryB a radius of curvature in 10 the local meridional section, at a point of intersection with the reference ray on the curved surface B, local\_ryA and local\_ryB have an identical sign and satisfy the following condition:

$$0.4 < \text{local\_ryA}/\text{local\_ryB} < 2.0.$$

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15 18. The image display apparatus according to Claim 13, wherein the optical surface A having the two functions of transmission and reflection, shared between the illumination optical system and the display 20 optical system, comprises only one surface.

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19. The image display apparatus according to Claim 13, wherein the reflected light from the display means emerge from the lens body and thereafter is 25 reflected by a plurality of reflective surfaces being decentered curvature surfaces to be guided to the pupil.

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16. The image display apparatus according to  
Claim 13, 14, or 15, wherein said illumination means is  
a time division light source for emitting a plurality  
of color light beams in time division and the display  
means displays images based on respective color beams  
in time division in synchronism with emission of the  
color light beams from the time division light source.

17. The image display apparatus according to  
Claim 13, 14, or 15, wherein the display optical system  
includes two or more surfaces with refracting powers  
differing depending upon azimuth angles, and the entire  
display optical system has a positive refracting power.

18. The image display apparatus according to  
Claim 13, wherein said lens body is comprised of a  
glass member.

19. The image display apparatus according to  
Claim 13, wherein said optical surface A and said  
curved surface B are cylindrical surfaces.

20. The image display apparatus according to  
Claim 13, wherein said optical surface A is a half  
mirror of metal.

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21. An image display apparatus comprising:  
reflective display means;

illumination means for illuminating the display means;

an illumination optical system for guiding light from the illumination means to the display means; and

5 a display optical system for guiding light from the display means toward an observer,

wherein the illumination optical system and the display optical system share an optical curvature surface A having two functions of transmission and reflection with each other, a curved surface B is provided on the opposite side of the optical curvature surface A to the display means, and the optical curvature surface A and the curved surface B compose a lens body, wherein rays emitted from the illumination means are reflected by the optical curvature surface A of the lens body to illuminate the display means, and the reflected light from the display means is transmitted by the optical curvature surface A, is incident to the lens body, emerges from the curved surface B, is reflected by a plurality of reflective surfaces, and thereafter is guided to the pupil to form an enlarged image of the image displayed on the display means, wherein in an outermost image on a local meridional section of the display means (a plane including incident light and exit light of a reference ray emitted from the illumination means and passing a center of an image on the display means and a center of

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an eye), when an F3 eye center ray represents a ray passing the center of the eye and an outermost image height F3 on the far side from the eye and when an F2 eye center ray represents a ray passing the center of the eye and an outermost image height F2 on the near side to the eye, an optical path length of the F3 eye center ray in the lens body in the display optical system is longer than that of the F2 eye center ray.

10 28. The image display apparatus according to  
Claim 21, wherein a curvature in the local meridional section of said optical curvature surface A of said lens body in said display optical system is larger than a curvature in the local meridional section of said curved surface B.

15 29. The image display apparatus according to  
Claim 22, wherein optical path lengths in the lens body in the display optical system of eye center rays at respective image heights, passing the image heights and the center of the eye on the local meridional section of said display means, become gradually longer from said F2 eye center ray side to said F3 eye center ray side.

25 24. A head mounted display comprising the image display apparatus as set forth in either one of Claims

1 to 4, 6 to 10, 12 to 15, and 18 to 23.

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26. A head mounted display comprising the image display apparatus as set forth in Claim 5.

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26. A head mounted display comprising the image display apparatus as set forth in Claim *16*.

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10 26. A head mounted display comprising the image display apparatus as set forth in Claim *16*.

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26. A head mounted display comprising the image display apparatus as set forth in Claim *17*.

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